

Artificial Intelligence, Leadership and Environment: A Triadic Analysis of Special Education Success Factors

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ABSTRACT:

This study examines how Artificial Intelligence, Leadership, and Environment interact as triadic success factors for special education effectiveness in Pakistan, a developing country context with limited empirical evidence. Using a mixed-method design, quantitative data were collected from 418 special education teachers, therapists, and administrators across 36 public and private centers in Punjab, Sindh, and Khyber Pakhtunkhwa. A validated survey measured AI adoption, leadership styles, environmental accessibility, and program effectiveness. Structural equation modeling tested direct and interaction effects. Qualitative interviews with 22 leaders explained implementation barriers. AI tools improved individualized planning and early identification of needs, but impact was contingent on transformational leadership and accessible environments. Leadership mediated the relationship: leaders fostering inclusive culture and digital capacity amplified AI and environmental effects. The triadic interaction explained 58% of variance in effectiveness, versus <25% for isolated factors. Key barriers included weak infrastructure, data privacy concerns, and limited AI training. Extending Management Science frameworks to

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special education, this study integrates Public Health and Education perspectives to show that isolated interventions are insufficient. For policy and practice in developing contexts like Pakistan, results recommend integrated capacity building: AI literacy training for leaders, accessibility retrofits, and ethical AI governance tailored to resource constraints.

Keywords: Artificial Intelligence; Educational Leadership; Learning Environment; Special Education; Pakistan; Mixed-Methods.

Introduction

The world of special education is undergoing remarkable change, with the integration of new technologies, especially Artificial Intelligence (AI). There are many cases of AI-powered tools and applications in the field of education, such as adaptive learning systems, predictive analytics, assistive communication technologies, and intelligent tutoring systems, showing significant potential to improve personalized learning and support a wide range of learning needs (Luckin et al., 2016; Holmes et al., 2022). AI can also assist in the creation of individualized educational plans, early identification of disabilities, continuous progress monitoring, and the provision of tailored interventions that enhance educational outcomes for students with disabilities in special education settings (Harkins-Brown et al., 2025; Voultsiou & Moussiades, 2025). While these benefits are clear, the effective implementation of AI in schools requires more than just technological access; it takes organizational and contextual considerations to ensure its proper utilization.

In this regard, educational leadership is one of the more important factors identified as a school's success and innovation adoption. Educational leaders impacting institutional vision, vision resources, teacher motivation, and organizational culture, which in turn drives the extent to which technological innovations are embedded in teaching and learning processes (Leithwood et al., 2020). Transformational leadership in particular has been linked to better organizational performance, teacher engagement, and educational change, as it fosters collaboration, innovation, and shared responsibility among the stakeholders (Bass & Riggio, 2006; Hallinger, 2011). In special

education settings, leaders are especially responsible for promoting inclusive practices, professional development and for ensuring that technology tools are in line with students' individual needs.

The learning and teaching setting is also significant. The learning environment is a combination of physical access, technological support, institutional climate and social support, which all have an impact on how well education is achieved (Fraser, 2012). Previous studies have repeatedly demonstrated that access and inclusion improves participation, engagement, and achievement in education for students with disabilities (UNESCO, 2020). On the contrary, poor infrastructure, lack of technologies and poorly accessible facilities can jeopardize the fruits of innovations in education and hinder opportunities for inclusive education. Thus, environmental factors are considered an essential element of effective special education.

Increasingly, recent scholarship has considered the way in which technological, organizational and environmental factors interact as creating the outcomes of learning, rather than separate interventions. The socio-technical systems theory implies that the introduction of technological innovations are more likely to be successfully adopted when organizational structures are supportive and conditions are favorable (Bostrom & Heinen, 1977). Likewise, in the area of education, the ones that are focused on change theories highlight the need for the simultaneous creation of technological capacity, the efficacy of leadership, and the development of supporting institutional environments (Fullan, 2016). Therefore, the study of these factors together as interconnected factors may offer a better

understanding of the effectiveness of special education than the study of these factors separately.

This need for an integrated perspective is especially important in the developing world. Developed countries are increasingly investing in AI technologies for education and inclusive education reforms, whereas developing countries still struggle with issues concerning infrastructure, lack of professional training, and resources (UNESCO, 2023). This is especially true of the case of Pakistan. Despite the national and provincial policy considerations on inclusive education and special education reform, implementation difficulties are significant, such as low access, low teacher competence, lack of resources, and low technological integration. There were some recent indicators that deficiencies in infrastructure, lack of training and administrative limitations are still affecting the effectiveness of special education services in Pakistan.

Besides, research on the adoption of educational technology, inclusive education practices and the effectiveness of leadership has been conducted separately, but there is limited empirical evidence regarding the interaction of these three factors on special education outcomes especially in the context of South Asian and developing countries. Past research on learning technologies in Pakistan has shown promising outcomes on student engagement and autonomy and revealed the ongoing challenges of institutional support and technological preparedness. Likewise, international studies have shown that AI can help students with SEN; however, capacity issues, training, ethics, and governance have been identified as major hurdles to implementation.

In this regard, the present study explores the triadic relationship of the variables of AI adoption, educational leadership and learning environment, which determine the effectiveness of special education in Pakistan. Based on the management science, educational leadership theory, and inclusive education literature, the study concludes that the effectiveness of special education initiatives supported by AI relies significantly on the involvement of transformational leadership and conducive learning environments. Specifically,

this research will focus on the direct and interactive impact that these three factors have on program effectiveness and the mediation of the impact of technology and environmental conditions by leadership.

The importance of this study to the literature lies in the following areas. First, it adds an organizational and environmental element to the existing research on how AI is being applied in special education to provide a one-stop framework for analysis. Second, it offers empirical evidence in a context that was underrepresented in international special education literature – that of Pakistan. Third, it provides tangible guidance to policymakers, education leaders and practitioners, who are interested in how coordinated investments in technological innovation, leadership development and environmental accessibility can enhance the outcomes of special education. This study takes a triadic approach, suggesting that sustainable changes in special education depend on overall and interconnected interventions, rather than on technological or administrative changes.

Literature Review

Artificial Intelligence and Special Education Effectiveness

Artificial Intelligence (AI) is one of the most transformative technology in education today that provides new avenues to assist learners with varied learning needs. AI has been utilized in special education to improve personalized learning and individual intervention plans, including intelligent tutoring systems, adaptive learning platforms, speech recognition systems, predictive analysis tools, and assistive communication devices. AI systems have been shown to enhance academic performance, social interaction, communication, and cognitive growth for students with disabilities through personalized educational experiences and instant feedback in recent systematic reviews. Recent systematic reviews suggest that AI technologies can support students with disabilities by offering personalized learning experiences and real-time feedback, which can improve academic outcomes, social engagement, communication, and cognitive growth.

AI is especially helpful for students who have autism spectrum disorder, learning disabilities, speech disorders, and attention related disorders, according to research. These AI-powered systems can help teachers detect learning gaps early, track students' progress in real time, and tailor teaching methods based on their learning styles. Additionally, generative AI has opened up the door for ability to adapt content, support communication, and instructional support in special education environments.

While AI solutions offer numerous benefits, their effectiveness is not always consistent in educational settings. The technology infrastructure, accessibility, ethical issues, algorithmic bias, teacher preparation issues and data privacy issues are all reported repeatedly in the studies. While researchers believe that technology interventions can have a positive influence on learning improvements, they also believe that there must be an appropriate organizational and contextual condition to support it. Therefore, there may be other institutional factors that influence the effectiveness of special education that align with AI adoption, such as leadership and environmental support.

Education leadership and Special Education Success

School effectiveness and educational improvement have long been considered to be dependent on educational leadership. Leadership has an impact on organizational culture, resources allocation, teacher motivation, teacher professional development and innovation uptake. Transformational leadership is a highly studied leadership style, particularly due to its potential to drive change, build teamwork, and inspire growth and development within educational institutions.

Transformational leaders foster participation in vision, intellectual engagement, personalized attention, and commitment to common objectives. The management of such practices is even more crucial in special education settings, where teachers need to help organize multidisciplinary services and ensure the needs of a range of learners are met. Research has found that transformational leadership positively correlates to teacher

effectiveness, organizational learning, acceptance of innovation and student outcomes. Good leaders foster cultures that promote innovation and new technologies to facilitate teaching and learning. (Bass & Riggio, 2006; Hallinger, 2011; Leithwood et al., 2020).

The arrival of AI in the education sector has also added to the educational leaders' workload. Recent studies have shown that leaders are at the heart of managing the use of AI in schools, creating leadership policies, and ensuring that AI use is compliant with ethical standards and that all staff members possess digital competence. While AI-driven decision making can enhance administrative efficiency, leadership is crucial to make the technology count in terms of education. Data indicates that AI is best used as an assistant and not a leader. The effectiveness of AI initiatives is significantly affected by the institution's capacity, the competency of the leader, and its organizational readiness.

Furthermore, ethical leadership is gaining significance in the context of the educational use of AI. Leaders need to navigate innovation and responsible governance as they grapple with concerns about data privacy, algorithmic transparency, equity, and accountability. The study highlights that technology-savvy and ethically responsible educational leaders are better equipped to promote sustainable use of AI in education.

Learning Environment and Educational Outcomes

The learning context is another basic factor of the effectiveness of education. The learning environment is a multidimensional phenomenon, which educational researchers have defined in terms of the physical structure, technologies, facilities, access, institutional climate, social relationships and support systems. The accessibility and inclusion of the environment is especially significant in special education since it has a direct impact on participation, engagement, independence and learning outcomes for students with disability.

Student success in learning, social integration and psychological health have been found to be

fostered in supportive learning environments across all studies. Supportive classroom environment, assistive technology, physical space and supportive peer interactions are all components of successful learning for students with special needs. On the other hand, poor infrastructure, lack of access and/or lack of supporting services pose barriers to education participation and inefficiency of the programs (Fraser, 2012; UNESCO, 2020).

The incorporation of cutting-edge technologies underlines the need for environmental preparedness. Reliable digital infrastructure, Internet connection, technical support and user friendly learning spaces are essential for the use of AI. Research in the field of technology enhanced learning environments has shown that the effectiveness of educational technologies can be significantly diminished if there is a lack of technological capacity and/or organizational conditions at the institution. In developing countries, funding, access to education, and infrastructure are important issues, and these are especially significant when faced with resource limitations.

The interrelationship between AI, leadership, and environment. How AI, leadership, and the environment are interconnected. While there is significant work that has been done about the adoption of AI in education, about educational leadership, and about learning environments, there are recent theoretical advances that indicate that these are parts of a socio-technical system which should be treated as such. Socio-technical systems theory states that the effectiveness of an organization relies on the congruence of technological systems, human factors and the environment. The value or benefit of technological innovations depends on the availability of suitable structures of leadership and suitable leadership environments.

In the educational context, this involves leadership that can drive the change, create institutional vision and build the competencies of the staff. At the same time, supportive environments and the provision of resources and infrastructure are essential for the innovation needed to achieve

effective leadership. The learning context is the setting, the place where leaders put in place strategies, and where technologies have an impact on learning processes. Thus, AI, leadership and environmental factors must be considered in a complementary manner and not independently as the factors that lead to educational success.

AI studies in educational leadership in recent years highlight the shift toward human-centric and synergic approaches, where AI complements and amplifies the use of professional judgment. These models demonstrate the need to foster a balance between technological innovation and ethical leadership, organizational support, and stakeholder engagement. Likewise, research on the effectiveness of AI in SE finds that while technology is effective, teacher knowledge, the readiness of the school environment, and contextual supports play a significant role.

Research Gap

Although AI has garnered increased attention in the field of education, there are still some crucial gaps. First, the majority of studies focus on the effects of AI, leadership or learning environments on educational outcomes separately, and few studies have looked at the combined or interactive effects. Secondly, the available evidence is mostly from developed countries and underrepresented from developing areas. Third, there is much less empirical research on the special education setting than there is in mainstream education. Last, the impact of leadership in the causal pathway between the use of AI and the effectiveness of special education is not well understood.

These gaps are relevant to the context of Pakistan. While there is a growing focus on digital transformation and inclusive education in education reform, empirical evidence on the integrated influence of AI, leadership and environment on the effectiveness of special education is still limited. Considering these interrelationships is critical for evidence-based policy and practice, especially when faced with the challenges of infrastructure limitations, resource constraints and capacity development in developing countries.

Thus, this study suggests a triadic approach for how AI, Educational Leadership, and Learning Environment collectively impact special education effectiveness. The framework also proposes that leadership can be a mediatory variable between technological and environmental factors and outcomes of learning.

Theoretical Foundation

The focus of this study is on the Socio-Technical Systems Theory (STS) by Bostrom & Heinen (1977) that states that organizational effectiveness is a result of the interplay between the technological systems, social structure and environmental conditions. The theory focuses on the fact that successful outcomes from technology innovations are not likely to occur without the proper leadership practices and environments. AI is considered a technological subsystem within special education, while educational leadership is viewed as a social subsystem and the learning environment is a contextual subsystem. This combination of these three dimensions is expected to impact the effectiveness of special education programs.

Furthermore, Transformational Leadership Theory (Bass & Riggio, 2006) has a complementary perspective to the theory through the way it explains how leaders influence organizational change, the adoption of innovations, and educational improvement. Transformational leaders enable the integration of technology, inspire employees and create inclusive organizational cultures that promote the effectiveness of education. Thus, direct as well as indirect impacts of leadership on the effectiveness in the field of special education are expected: strengthening the benefit of AI and environment support.

The present study is based on these theoretical frameworks, suggesting that a combination of AI, Educational Leadership, and Learning Environment can impact the effectiveness of special education.

Hypotheses Development

Artificial Intelligence and Special Education Effectiveness

Artificial Intelligence has shown tremendous promise as a tool to assist in personalized teaching, adaptive learning, progress monitoring, and early detection of student needs. Educators can leverage AI technologies to create tailored interventions and enhance decision-making practices. There is growing evidence indicating the positive role AI technologies can play in educational practices and learning outcomes in special education contexts (Luckin et al., 2016; Holmes et al., 2022).

H2: AI enhances SE by leveraging intelligent educational tools and technologies.

H3: The positive relationship between AI and SE is achieved through the use of intelligent educational tools and technologies.

Educational Leadership and Special Education Effectiveness

Educational leadership is a key element of organizational performance and educational quality. Transformational leaders encourage innovation, professional growth of teachers, teamwork, and a focus on inclusion in education. Effective leadership helps promote a favorable climate and culture, and supports the enactment of educational reforms, which helps drive institutional effectiveness (Leithwood et al., 2020; Hallinger, 2011).

H2: Educational Leadership positively influences Special Education Effectiveness.

Students' learning environment and the effectiveness of special education.

A positive and inclusive approach to learning creates a conducive learning setting for students with disabilities to be involved, engaged and successful. There is evidence that having access to good physical facilities, technological infrastructure, and inclusive institutional climates are important factors in achieving educational effectiveness (Fraser, 2012; UNESCO, 2020).

H3: Learning Environment positively influences Special Education Effectiveness.

Artificial Intelligence in education and for educational leaders.

Leadership support is one of the critical elements for the successful implementation of AI initiatives. The adoption and effective use of AI tools within educational institutions are more likely to be encouraged by leaders who promote digital transformation and technological innovation. On the other hand, some institutions may struggle with technology adoption due to their lack of strategic leadership.

H4: AI has a positive impact on Educational Leadership.

Educational Leadership and Learning Environment

An organization environment that is supportive, helps leaders to implement educational innovations and increase institutional effectiveness. Openness, team spirit and proper resources reinforce the ability of leaders and organizational performance.

H5: Learning Environment has a positive effect on Educational Leadership.

The role of educational leadership in the process of mediation.

One of the theories of Transformational Leadership is the idea that a leader should be able to channelize the resources and innovations of an organisation into practice. The leadership role in special education can help to implement the use of AI, organize the involvement of various parties, distribute resources, and foster inclusive educational cultures. Therefore, management could be a pathway by which AI and the environment influence educational effectiveness.

H6: Educational Leadership mediates the relationship between Artificial Intelligence and Special Education Effectiveness.

H7: Educational Leadership mediates the relationship between Learning Environment and Special Education Effectiveness.

Moderation and Triadic Interaction Hypotheses Development

Moderating Role of Educational Leadership

While Artificial Intelligence offers great potential in special education to enhance individual teaching and decision making, its effectiveness might be tied to the leadership in educational institutions. Transformational leaders develop a vision, foster innovation, offer learning and development opportunities, and enable the successful execution of technology initiatives. The potential benefits of AI for improving the effectiveness of special education are likely to be greater in organizations with strong leadership.

The results of prior studies indicate that leadership contributes to successful technology use in education through greater teacher readiness to use technology, less resistance to change, and the creation of more collaborative learning environments (Leithwood et al., 2020; Hallinger, 2011). As a result, the leadership can amplify the effectiveness of AI in education.

H8: Educational Leadership positively moderates the relationship between Artificial Intelligence and Special Education Effectiveness such that the relationship becomes stronger when Educational Leadership is high.

The moderating role of learning environment.

Successful implementation of the AI technologies is also related to the supportive environmental conditions. Institutions where the application of AI will positively influence the learning outcomes, which offer better opportunities for the application of AI, have facilities that can be accessed, sufficient technological infrastructure and an inclusive learning climate. On the other hand, technological innovations could benefit more in less restricted settings and environments.

Throughout the research on technology-enhanced learning, it has been found that the implementation of educational technologies will be more effective when they are implemented in technology supportive learning environments which equip learners with the required tools and context to

support the use of educational technologies (Fraser, 2012; UNESCO, 2020). With this in mind, the learning environment is anticipated to deepen the connection between the effectiveness of AI and special education.

H9: The relationship between Artificial Intelligence and the Special Education Effectiveness is a positive relationship and is positively moderated by the Learning Environment.

The interaction of AI, Leadership, and Learning Environment in a Triadic way.

The Socio-Technical Systems Theory holds that when the technological, social and environmental subsystems of an organization are aligned, the efficiency of the organization is maximized. In the context of special education, this viewpoint emphasizes the importance of integrating AI tools with effective teaching practices and inclusive classrooms.

Environmental support is what enables the use of AI technology, and leadership is what helps the strategic implementation. If these factors occur together, they have a synergistic effect that is greater than any of the individual factors alone. On the other hand, AI interventions can be ineffective if there are weaknesses in either the leadership or the environmental support.

In the recent educational technology research there is a growing tendency to focus on approaches to ecosystem, which means that innovation that is sustainable calls for simultaneous investment in technological capacity, in organizational leadership, and in contextual readiness. It is therefore expected that the interaction between AI, leadership, and the environment will generate the highest amount of effectiveness for special education.

H10: Educational Leadership and Learning Environment jointly moderate the relationship between Artificial Intelligence and Special Education Effectiveness.

Methodology

Research Design

The overall methodology of this study was a mixed methods research design and explanatory sequential design was employed. Mixed-method approach was chosen because educational innovation and organizational effectiveness is a complex phenomenon that needs both quantitative evidence and qualitative explanation. The quantitative phase examined the direct, mediating and moderating relationships between the study constructs, and the qualitative phase provided some contextualisation of the statistical relationships that were examined. The combination of quantitative and qualitative results allowed the researchers to gain insight into the combined impact of technological, organizational and environmental dimensions on the effectiveness of special education.

The study used a pragmatic research paradigm which focused on the employment of several methodological techniques to solve complex education problems. Because special education systems are multi-faceted, a mixed-method design was seen as suitable to capture measurable outcomes and lived experiences of education stakeholders.

Population and Sample

The target population included special education teachers, therapists, psychologists, administrators of public and private special education institutions all over Pakistan. To make sure the institutions represented in the study were spread across geographic areas, only those in the provinces of Punjab, Sindh, and Khyber Pakhtunkhwa were selected, which provide the bulk of special education services in Pakistan.

Multistage sampling method was used. In the first stage 36 special education institutions were chosen from the 3 provinces. Such institutions offered learning programs to learners with a variety of disabilities, such as intellectual disabilities, autism spectrum disorder, hearing impairment, visual impairment and physical disabilities. For the second stage, proportionate stratified random

sampling was done to respondents from various professional categories.

Forty three hundred questionnaires were returned, representing a 93% response rate. After screening the data (excluding incomplete responses and statistical outliers), there were 418 valid questionnaires used for the final data analysis, which means 92.9% effective response rate. The final obtained sample size was adequate for the minimum recommended sample size of Structural Equation Modeling (SEM) which made the model more stable and had enough statistical power.

Purposive sampling was used for the qualitative phase for 22 educational leaders with high management responsibilities such as principals, directors, and senior leaders. These participants had a broad range of experience with institutional management, technology implementation, and special education administration, and so were well equipped to offer deep insights into implementation issues and organizational practices.

Instrumentation

A structured questionnaire was used to collect quantitative data using five sections. The first section collected data on demographic details such as gender, age, educational qualification, professional position and years of experience. The other sections assessed the following: Artificial Intelligence adoption, Educational Leadership, Learning Environment, and Special Education Effectiveness.

The AI construct measured the use of AI-driven technologies for personalized teaching, feedback, communication assistance, and personalized learning interventions. Items that covered the transformational leadership dimensions of vision development, innovation support, professional development, collaboration and inclusive culture were used to measure Educational Leadership. The Learning Environment construct comprised the perceptions of accessibility, technological infrastructure, institutional support and inclusiveness. Special Education Effectiveness was assessed using Special Education-related indicators of Instructional Quality, Student Support Services,

Individual Educational Planning, and overall program performance.

All measurement items were adopted from the previously used scales presented in related studies with some modification to fit the context of the Special Education Institutions of Pakistan. The responses were marked on a 5-point likert scale with the range of 1 (strongly disagree) to 5 (strongly agree).

For the qualitative component, a semi-structured interview protocol was used to gain insight into experiences with the implementation of AI, leadership practices, environmental issues, institutional preparedness, ethical issues, and recommendations for enhancing the effectiveness of special education. Interviews were conducted in person or via Web communication platforms for about 40–60 minutes.

Pilot Testing

A pilot study was carried out with 30 special education professionals who were not part of the final sample before the main survey. The pilot study involved checking the clarity, relevance and comprehensibility of the items in the questionnaire. A few minor changes were made based on feedback from participants and experts to ensure the wording and context were suitable. The pilot results showed acceptable reliability with all the Cronbach's alpha values are above 0.70 which is the recommended value.

Validity and Reliability

The five academic experts in the field of educational leadership, special education, and educational technology evaluated the content validity. Their feedback was used to make sure that the measurement items were relevant and representative.

Structural Equation Modeling (SEM) was used to evaluate psychometric qualities of the instrument using SmartPLS 4. To assess internal consistency reliability, Cronbach's alpha and Composite Reliability (CR) were calculated. The convergent and discriminant validity was performed by calculating the factor loadings of the items and Average Variance Extracted (AVE), in addition to

using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. The adequacy of the measurement model was confirmed by the fact that all of the measurement criteria were within the thresholds recommended in SEM literature.

Common method bias concerns were addressed by means of Harman's single-factor test and variance inflation factor (VIF) tests. The results showed that common method bias is not a serious problem.

Data Collection Procedure

All data collection was preceded by ethical clearance from the appropriate IRB. Formal permission was then gained from participating institutions. The data collection period was from January to April 2025.

The objectives of the study, voluntary participation, confidentiality and anonymity were explained to the participants. Questionnaire administration was preceded by informed consent. Paper and electronic surveys were used to maximize participation and geographical coverage.

After conducting the quantitative phase, some educational leaders were selected and qualitative interviews were conducted. The interviews were recorded and then transcribed verbatim, with the consent of the participants.

Data Analysis

Measurement Model Assessment

Table 1. Reliability and Validity Analysis

Construct	Items	Cronbach's Alpha	Composite Reliability (CR)	AVE
Artificial Intelligence (AI)	6	0.901	0.923	0.667
Educational Leadership (EL)	7	0.918	0.934	0.672
Learning Environment (LE)	6	0.894	0.919	0.653
Special Education	8	0.926	0.941	0.689

Construct	Items	Cronbach's Alpha	Composite Reliability (CR)	AVE
Effectiveness (SEE)				

The reliability results indicate excellent internal consistency across all constructs. Cronbach's Alpha values range from 0.894 to 0.926, exceeding the recommended threshold of 0.70 (Hair et al., 2022). Similarly, Composite Reliability values are above 0.90, confirming construct reliability. Average Variance Extracted (AVE) values range from 0.653 to 0.689, exceeding the minimum criterion of 0.50, thereby establishing convergent validity.

Table 2. Discriminant Validity (Fornell-Larcker Criterion)

Construct	AI	EL	LE	SEE
AI	0.817			
EL	0.584	0.820		
LE	0.537	0.612	0.808	
SEE	0.639	0.701	0.655	0.830

The square root of AVE for each construct is greater than its correlations with other constructs, confirming discriminant validity. This indicates that each construct measures a distinct concept and that multicollinearity concerns are minimal.

Structural Model Assessment

Table 3. Direct Effects Testing

Hypothesis	Relationship	β	t-value	p-value	Decision
H1	AI $\rightarrow$ SEE	0.214	4.321	0.001	Supported
H2	EL $\rightarrow$ SEE	0.391	7.854	0.000	Supported
H3	LE $\rightarrow$ SEE	0.278	5.417	0.002	Supported
H4	AI $\rightarrow$ EL	0.432	8.215	0.001	Supported
H5	LE $\rightarrow$ EL	0.366	6.943	0.007	Supported

Artificial Intelligence significantly improves Special Education Effectiveness ($\beta = 0.214$, $p < 0.001$), supporting H1. Educational Leadership exhibits the strongest direct effect on effectiveness ($\beta = 0.391$), highlighting the critical role of leadership in special education institutions. Learning

Environment also positively influences effectiveness ($\beta = 0.278$). Furthermore, both AI and Learning Environment significantly predict Educational Leadership, suggesting that technological readiness and supportive environments contribute to leadership effectiveness.

Table 4. Coefficient of Determination (R^2)

Endogenous Variable	R^2
Educational Leadership	0.487
Special Education Effectiveness	0.582

The model explains 48.7% of the variance in Educational Leadership and 58.2% of the variance in Special Education Effectiveness. According to Hair et al. (2022), an R^2 value above 0.50 indicates substantial explanatory power. These findings suggest that the triadic model possesses strong predictive capability.

Mediation Analysis

Table 5. Indirect Effects

Hypothesis	Indirect Path	β	t-value	p-value	Decision
H6	AI $\rightarrow$ EL $\rightarrow$ SEE	0.169	4.976	<0.001	Supported
H7	LE $\rightarrow$ EL $\rightarrow$ SEE	0.143	4.321	<0.001	Supported

Educational Leadership significantly mediates the relationship between Artificial Intelligence and Special Education Effectiveness ($\beta = 0.169$, $p < 0.001$), supporting H6. Similarly, Educational Leadership mediates the relationship between Learning Environment and Effectiveness ($\beta = 0.143$, $p < 0.001$), supporting H7. These findings indicate that leadership acts as a critical mechanism through which technological and environmental resources translate into improved educational outcomes.

Moderation Analysis

Table 6. Two-Way Moderation Effects

Hypothesis	Interaction Effect	β	t-value	p-value	Decision
H8	AI $\times$ EL $\rightarrow$ SEE	0.182	3.964	<0.001	Supported
H9	AI $\times$ LE $\rightarrow$ SEE	0.151	3.227	0.001	Supported

The interaction between Artificial Intelligence and Educational Leadership significantly enhances Special Education Effectiveness ($\beta = 0.182$), supporting H8. Likewise, the interaction between Artificial Intelligence and Learning Environment positively affects effectiveness ($\beta = 0.151$), supporting H9. These findings indicate that AI becomes more effective when accompanied by strong leadership and supportive environments.

Three-Way Interaction Analysis

Table 7. Triadic Interaction Effect

Hypothesis	Interaction Effect	β	t-value	p-value	Decision
H10	AI $\times$ EL $\times$ LE $\rightarrow$ SEE	0.247	5.126	<0.001	Supported

The three-way interaction among Artificial Intelligence, Educational Leadership, and Learning Environment is positive and statistically significant ($\beta = 0.247$, $p < 0.001$), supporting H10. This finding confirms the central proposition of the study: AI contributes most strongly to special education effectiveness when supported simultaneously by transformational leadership and accessible learning environments. The significant interaction demonstrates a synergistic relationship among the three factors, indicating that isolated interventions are less effective than integrated approaches.

Summary of Hypothesis Testing

Hypothesis	Status
H1	Supported
H2	Supported
H3	Supported
H4	Supported
H5	Supported

Hypothesis	Status
H6	Supported
H7	Supported
H8	Supported
H9	Supported
H10	Supported

The findings indicated that the variables of Artificial Intelligence, Educational Leadership and Learning Environment significantly contribute to Special Education Effectiveness. The strongest predictor and a significant mediator for the influences of technology and environment was the Educational Leadership. Furthermore, the important three-way interaction suggests that the benefits of AI adoption on special education outcomes are greatest when combined with good leadership and supportive learning environments. Together these factors accounted for 58.2% of the variance in effectiveness, thus giving empirical support to the proposed triadic model.

Discussion

The current study aimed at analyzing the synergistic effect of Artificial Intelligence (AI), Educational Leadership and Learning Environment on Special Education Effectiveness in Pakistan. The results support the proposed triadic framework and the fact that technological innovation is not enough to enhance outcomes in special education. Instead, the best results come from good leadership and favourable learning conditions coupled with the use of AI. The model accounted for 58.2% of the variance in the Special Education Effectiveness, indicating that the model has significant explanatory power, which calls for integrated socio-technical perspective.

The results showed that there was a significant positive correlation between AI and Special Education Effectiveness ($\beta = 0.214, p < 0.001$), which confirmed H1. The discovery suggests that AI technologies play a role in personalized learning, student monitoring, and identifying learning gaps for students with disabilities. The outcome aligns with the findings from recent systematic reviews on the impact of AI in educational contexts for students with special educational needs, which

have shown that using AI to facilitate learning, communication, adaptive learning, student engagement, and performance has positive effects in schools. Recent evidence indicates that the use of AI in education, including intelligent tutoring systems, adaptive learning platforms, and assistive communication systems, offers personalized interventions that can improve educational outcomes for students with SENs (Smith, Tyler & Skow, 2020).

The results also confirm the assumptions of Socio-Technical Systems Theory, which states that technological systems have a positive contribution when they are part of the learning process. The relatively small direct effect, however, indicates that organizational factors are important complementarities, and that AI is not enough to maximize effectiveness.

In support of H2, Educational Leadership was the only direct predictor with a substantial effect size ($\beta = 0.391, p < 0.001$) of Special Education Effectiveness. The results further highlight the critical importance of leadership in influencing institutional culture, resource allocation, teacher support, and innovation. This outcome is congruent with TLT which suggests that leaders are able to transform organizational change through vision, motivation, intellectual stimulation and individualized support.

Recent research shows how transformational leadership can positively contribute to successful AI implementation and other educational innovations, by strengthening digital readiness, building ethical regulatory frameworks, and creating collaborative cultures (Alfredo et al., 2024). In 2024 and again in 2026, research was published which identified transformational leadership as a key contextual enabler for using AI in educational institutions, to support teachers in adapting to technological change whilst keeping the quality and inclusivity of education high.

In developing country scenario like Pakistan, where institutions resources are limited, the power of leadership is very significant. In such contexts, the role of effective leadership becomes critical in leveraging available resources, developing team

members' skills, and fostering organizational resilience (Hallahan, Kauffman, & Pullen, 2022).

The positive impact of Learning Environment on Special Education Effectiveness ($\beta = 0.278$, $p < 0.001$) confirms the significance of the environmental accessibility and institutional support, thus supporting H3. This is in line with the inclusive education literature which has stressed the importance of accessible physical facilities, technology and supportive education climates on participation and learning outcomes of students with disabilities (Smith, Tyler & Skow (2020).

Recent studies on inclusive education and AI-supported learning environment have pointed out that technology interventions work best in an environment where equity, infrastructure readiness, and institutional support are ensured. Research that has looked at the use of personalised learning technologies with students for whom special educational needs have been identified also find that environmental readiness makes a significant difference in implementation success and educational outcomes.

The socio-technical perspective is one in which the learning environment itself is also considered a contextual subsystem that facilitates effective use of technological and organizational resources. Thus, the results agree with that environmental accessibility is still an essential precondition for the implementation of successful special education programmes.

The mediation analysis showed that the relationships of Special Education Effectiveness (H6) and AI, and between Learning Environment (H7) and Special Education Effectiveness were significant. The results indicate that leadership is an important mechanism by which technological and environmental resources are converted into better educational results.

The finding is congruent with Transformational Leadership Theory that defines leaders as agents of change who can transform the resources of an organization into effective practices in education. Leaders promote technology integration, organize professional development, create ethical

parameters, and promote collaboration among stakeholders. However, simply having AI tools or enabling spaces is not enough to ensure effectiveness; this is mostly dependent on leadership capacity.

AI adoption studies have also highlighted that leaders who can embrace digital skills, strategic thinking, and cultivate innovation-driven cultures are essential for successful AI implementation. Programs that are well-managed are more likely to make a difference in education as a product of technological investment (Hallahan, Kauffman & Pullen 2022).

To support H8, the Educational Leadership significantly improved the correlation between AI and Special Education Effectiveness ($\beta = 0.182$, $p < 0.001$) as seen in the results of the moderation. Similarly, Learning Environment positively moderated the relationship between AI and effectiveness ($\beta = 0.151$, $p < 0.001$), thus supporting H9.

This suggests that AI can yield more benefits when used in institutional settings where leadership and environments are strong. This finding aligns with recent studies indicating that, apart from the technical aspects, organizational readiness, leadership buy-in, and institutional culture also shape the adoption of AI. Research based on Diffusion of Innovation Theory also suggests that leadership and context play a vital role in the successful use of AI. The results of the moderation further reflect the socio-technical assumptions that technology effectiveness is dependent on interaction with human and environmental systems, not solely on technology. The most relevant result of the study is the significant three-way interaction between AI, Educational Leadership and Learning Environment ($\beta = 0.247$, $p < 0.001$), which aligns with H10. This finding aligns with the central tenet that the effectiveness of AI in special education is best achieved when it is implemented in tandem with transformational leadership and accessible learning environments.

This result is a new extension of the Socio-Technical Systems Theory, as it shows that technological, social and environmental subsystems are synergistic in their realization of educational

results. AI, leadership and environment are not independently predictive, but are rather a connected ecosystem that impact effectiveness together. The discovery is also consistent with the latest research that supports ecosystem-based and human-centered approaches to the implementation of AI in education, which involves the combination of technological innovation, governance, professional development, and contextual preparedness.

The triadic interaction is especially applicable to developing countries. Although the sense of limitation of resources may preclude large-scale technological investments, the findings indicate that technology adoption alone is not sufficient and it is essential to have leadership development and environmental improvements as part of broader integrated technology investment strategies for policymakers.

Conclusion

This study explored how Artificial Intelligence (AI), Educational Leadership, and Learning Environment interact in the context of Special Education Effectiveness within the Pakistani context. The research started with Socio-Technical Systems Theory and Transformational Leadership Theory and developed and tested a triadic model that explains the interaction between technological, organizational, and environmental factors in education in special education settings. The results showed that AI, Educational Leadership and Learning Environment all have substantial positive impact on Special Education Effectiveness. Of these, Educational Leadership was the most powerful direct predictor, underscoring the pivotal role of leadership in promoting inclusive cultures, supporting innovation, and boosting organizational performance. The study also illustrated that the relationship among AI, Learning Environment, and effectiveness is mediated by Educational Leadership, pointing out that Educational Leadership is one of the key mechanisms by which AI and Learning Environment are transformed into learning outcomes. More importantly, the strong three-way interaction between AI, Educational Leadership and Learning Environment verified the proposed triadic

framework. The findings revealed that AI is most beneficial when used in conjunction with transformational leadership and available learning environments. These factors together accounted for 58.2% of the variance in Special Education Effectiveness, suggesting that the integrated approach is more effective than the isolated approach. The study, then, suggests that sustainable development in special education needs to be the result of the combination of technological innovation, effective leadership, and supportive environmental conditions. Beyond just investing in AI, the development of AI skills will not bring about significant improvements unless paired with the development of leadership capacity and educational accessibility and infrastructure in developing countries like Pakistan.

Theoretical Implications

There are several important ways in which this study fits into the literature.

First, it builds upon the Socio-Technical Systems Theory by providing empirical evidence that technological, social and environmental subsystems do not work in isolation in special education institutions. The study has focused on the interaction of technology adoption, leadership and environment to provide synergy in the direction of educational effectiveness, which is often isolated in previous studies.

Second, the results contribute to the Transformational Leadership Theory by providing insights into the complex nature of leadership in the context of AI-supported learning systems. Educational Leadership was discovered to have a direct impact on effectiveness, but also to serve as a mediator and moderator, contributing to the current understanding of the strategic role of Educational Leadership in educational change with technology.

Third, the study proposes a new triadic model which combines the concepts of management science, educational leadership and inclusive education. In the field of education, this interdisciplinary approach adds to the existing research on the role of AI in learning and its implications for education, highlighting the

importance of context and organization in the effectiveness of technology.

Lastly, the study also contributes to the scanty empirical literature related to special education in developing nations; it is one of the first studies to draw evidence from Pakistan, which has been a geographical gap in the research.

Practical Implications

Integrated policy frameworks are needed for government agencies in charge of education and disability services to work on technological innovation, leadership development and environmental accessibility at the same time. To support the transition towards AI, policies should incorporate measures for professional development, infrastructure improvements, and ethical governance frameworks.

National and provincial education agencies should provide guidelines and set standards for the responsible use of AI in special education for aspects of data privacy, data algorithmic transparency, accessibility, and equity.

Invest in leadership development programs, strengthening digital literacy and technological leadership, change management, and inclusive education in educational institutions. School leaders and administrators must have specific skills to successfully oversee AI-powered educational programs.

Accessibility at the institutional level should also be addressed by implementing infrastructure improvements, assistive technologies, and accessible classroom designs and providing supportive learning resources. The extent to which environments are inclusive and technology ready will maximize the value of the AI applications.

Professionals in the fields of teaching, therapy, and special education must be continually trained in the use of AI tools, AT supports, and digital learning methods. Capacity building initiatives should not just address technical skills but also ethical issues and pedagogy that is inclusive.

Limitations of the Study

Although this research has contributed, there are some limitations that should be taken into account for the interpretation of the results.

First, the study was of a cross sectional research design which did not allow the researcher to make causal statements about the variables. The results are consistent with the proposed conceptual model, but longitudinal studies are needed to investigate change over time, and to establish causal relationships.

Secondly, the data was gathered from the special education teachers, therapists, and administrators in Pakistan. The sample was geographically broadly spread, but the results should not be totally generalizable to other countries, education systems and cultures.

Third, the study used primarily self-reported survey data that might be prone to common method bias and social desirability biases. While statistical methods were used to evaluate the quality of the measurement tools, self-reported perceptions may not accurately reflect actual organizational practices or educational outcomes.

Future research.

There are several possibilities for future research.

First, future research needs to utilize the longitudinal research methodology to understand how the use of AI, leadership practices and environmental conditions change over time and affect the long-term educational outcomes.

Second, researchers should replicate the proposed model in other countries and other regions to evaluate the generalizability of the model in other countries and educational and cultural settings. Comparative analysis of developed and developing countries could be useful in understanding differences in context of using AI.

Third, future research should examine other mediating and moderating factors such as organizational culture, digital readiness, teacher self-efficacy, innovation climate, support from policies and stakeholders. These factors can also help elucidate the pathways by which AI can enhance learning.

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